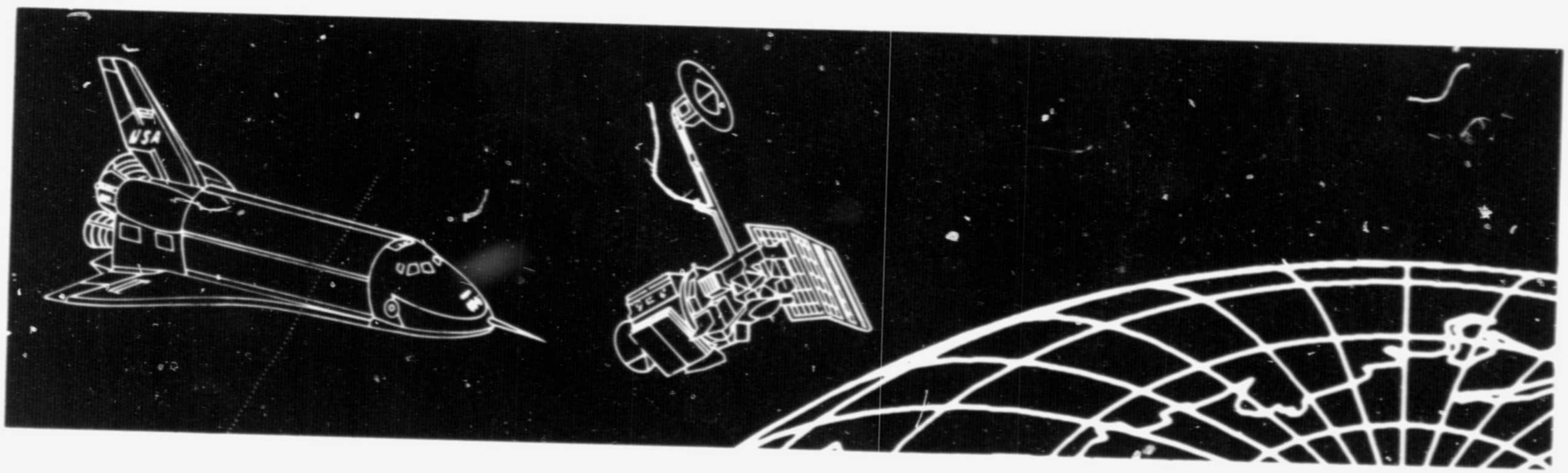
Earth Resources Satellite
Data Applications Series

Satellite Earth Resources Data

Module U-3 January 1980



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Preface

With the increasing interest in Landsat data by the private and public sectors, the availability of pertinent information for potential users is of vital concern. Introduction of the Earth Resources Satellite Data Applications Series of publications is directed toward bridging that gap which often arises between fast-paced technology development and the availability of practical results to the user community. This series of publications is intended to be responsive to needs of the public and private sectors for practical guidance to the disciplinary, functional, and educational uses of Earth Resources Satellite Data.

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Office of Space and Terrestrial Applications
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Contents

Introduction

NASA is frequently asked to provide information on space missions and systems that acquire Earth observation data which may have practical as well as scientific uses. This module describes and illustrates satellite data image products which are potentially useful in solving Earth resources and environmental problems. Hopefully, this publication will encourage researchers and problem solvers to make more use of satellite data products which are new, rapidly improving, and offer relatively inexpensive global data sets. Major emphasis is placed on current satellite systems, such as Landsat, that are providing imagery which is readily available to all users. In addition, information on past and future satellite systems is summarized in tabular form. Sources for obtaining the data products described are noted at the end of each system or mission discussion.

The purpose of this document is to present an overview, rather than a detailed discussion, of the various types of Earth resources image data acquired by both automated and manned satellite systems. Potential users of satellite data should obtain and review the appropriate **Data Use Modules** provided in the NASA **Earth Resources Satellite Data Application Series**. Additional details and descriptions of the satellite systems and their data products discussed herein, can be found in the user publications listed on the last page of this document.

...ginal photography may be purchased from
EROS Data Center
Sioux Falls, SD 51798

Comparison of Aircraft and Satellite Data

Although not nearly as common as aircraft photography, satellite data, if used appropriately, can be an extremely cost-effective data base. The main advantage of Earth observation from either automated satellites (Landsat) or manned spacecraft (Skylab) is the large area view of land features and ocean characteristics. However, this synoptic view does not provide small detail in images of ground features, which can be obtained by aircraft photography. The large ground area captured in a single scene from a satellite sensor can preclude the need to compile mosaics from aerial photographs. This is particularly useful in studying large geographic areas such as in geologic surveys, watershed analyses, and land cover/use classification of a regional nature.

The imagery obtained from orbital surveys can be interpreted and utilized much like high altitude aerial photography. Moreover, the satellite imagery is in digital form, includes spectral bands unavailable through conventional photography, and allows adaptive data manipulation for a wide range of user needs. Earth resources data from satellites can be used in individual (black and white) spectral bands or combined into multiband false-color composites resembling color infrared aerial photography. Additionally, some data, such as that acquired by Landsat, are provided repetitively and are therefore useful in change detection studies.

The accompanying figures further illustrate the comparison of aircraft and satellite data.

Standard Landsat Image (Band 5), of Central Washington State, July, 1975 (Original Scale 1:1,000,000)

Portion of Landsat Color Composite Image of Central Washington July 1975, (Scale 1:100,000,000)	Enlargement of Boxed-in Area of Landsat Scene (Scale 1:130,000)	High Altitude Aircraft (U-2) Color IR Photograph of Boxed-in Area, July 1978 (Scale 1:130,000)

Comparison of satellite (Landsat) and aircraft (U-2) images. The Landsat image was recorded in July 1975, from an orbital altitude of 900 km. The U-2 color infrared photo was taken in 1978 from an altitude of 20 km (65,000 feet). The most striking features in the 10 x 20 km boxed-in area are the circular fields under irrigation. Note in the 1978 photograph that several additional irrigated fields have been added to the area since 1975.

Satellite Sources of Earth Resources Data

Landsat data are the most available and commonly used satellite Earth resources data, but other sources of unique and potentially valuable satellite data are also available (see the chart below). However, most satellites have unique data distribution systems which require users to access each satellite data base differently. A table at the end of this publication identifies the major satellite remote sensing systems which provide Earth resources data and describes the imagery of the various sensors. The reader is reminded that remote sensing from space is a very dynamic program area within NASA and cooperating federal agencies. New missions are planned to provide better quality data and improved delivery of data to the user. The more significant future satellite remote sensing systems are also included in the above mentioned table. A brief description of the major types of satellite Earth resources data and some examples are presented in the following pages.

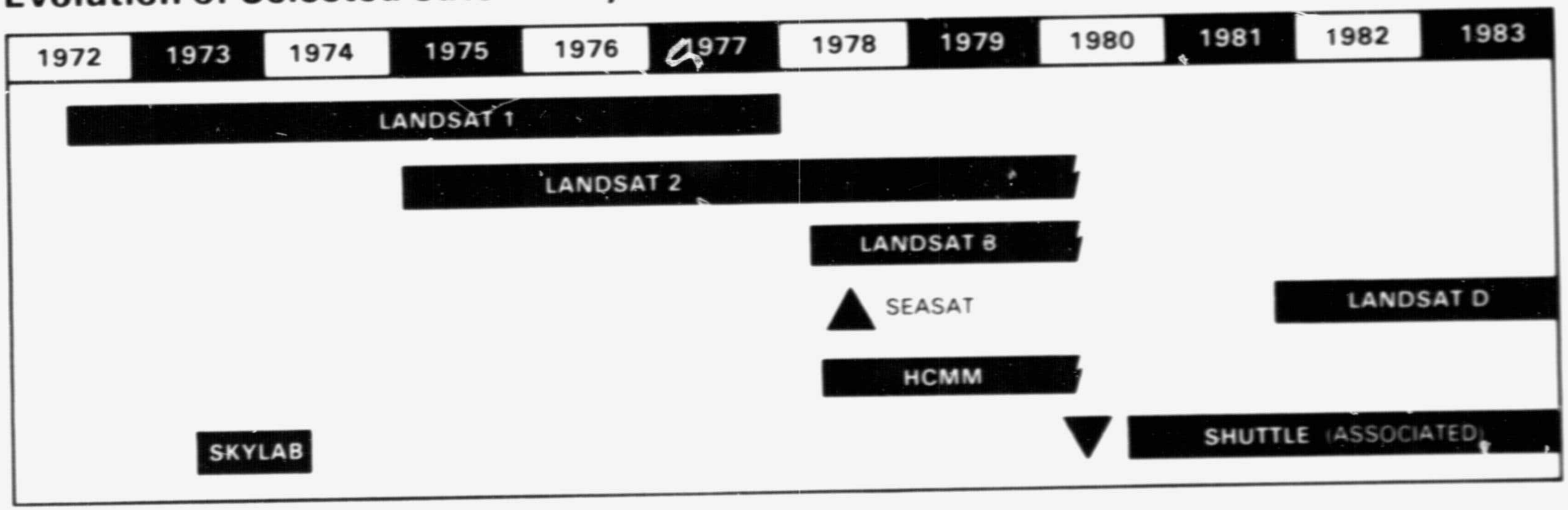
Manned Satellites

Gemini-Apollo Photography. The first extensive collection of orbital photographs of the Earth's surface was acquired by the NASA manned Gemini and Apollo missions during 1965-1969. Most of these photographs acquired by handheld 70 mm cameras, are panchromatic or color images, and each covers an area of 160 x 160 km. These missions yielded about 4,000 black and white, color, and multiband photographs of the Earth's surface and are available from the EROS Data Center.*

Skylab Photography. During the NASA Skylab Program in 1973-1974, more sophisticated photographs were acquired over selected

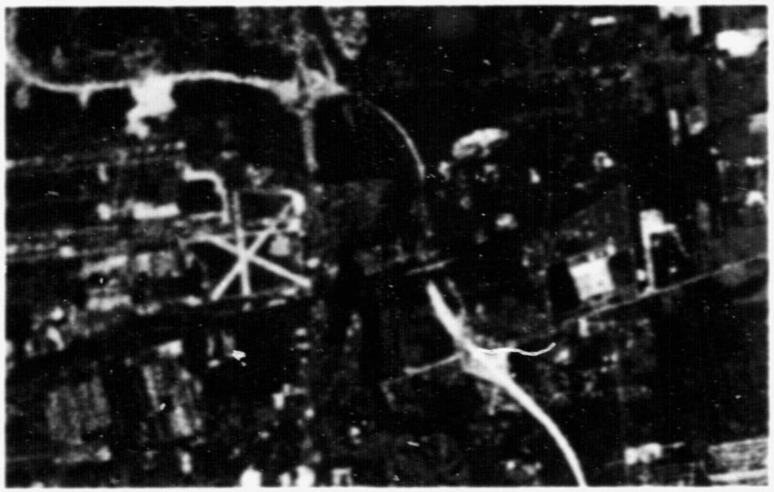
*Addresses of referenced organizations are provided in the back pages of this publication.

Evolution of Selected Satellite Systems for Observing Earth Resources



NASA RB-57 color infrared photograph (August 28, 1973) of the eastern periphery of Columbus, Ohio (Scale 1:75,000)

Skylab S190B color infrared photograph (August 15, 1973) of the same area shown above



areas of the United States between 50° N and 50°S latitudes. These are being used occasionally in current Earth resources studies. The most useful Skylab imagery is the high-resolution (~25 m) photography, acquired over selected areas, using the Earth Terrain Camera (S190B) with panchromatic, color, and color infrared film. The area covered by each frame of this imaging system was 95 x 95 km. Other useful and more extensive Skylab imagery acquired over selected areas of the United States was obtained by the six-camera, Multispectral Array (S190A). Each camera in the array used 70 mm film which provided black and white, color, and color infrared photographs. The area covered by each photograph was 144 x 144 km with an average ground resolution close to that obtained by the Landsat series (~80 m). All Skylab Earth resources data are available from the EROS Data Center.

Automated Satellites

Meteorological Satellites. The first data from automated satellites to be utilized for Earth resources survey applications came from the meteorological series: TIROS, NOAA, and Nimbus. These operational satellites provide low resolution (>1 km) imagery and/or digital data in the visible and thermal infrared (IR) regions. The data are currently utilized in large area studies such as regional geologic surveys and small scale thermal change monitoring of coastal waters. All imagery and limited digital data are available from NOAA's Satellite Data Services Division.

Heat Capacity Mapping Mission (HCMM). This is another low-spatial resolution (500 m) satellite containing a 2-band thermal IR scanning system capable of providing 0.5° C temperature resolution. The satellite, launched in 1978, is an experimental satellite--which means data (digital tapes and imagery) generated will be primarily for mission investigators. HCMM data are being evaluated for discriminating rock types and mineral resource locations, measuring soil moisture, mapping thermal effluents, and monitoring snow fields for water runoff predictions. Interested users should contact the HCMM Mission Utilization Office at NASA GSFC or the National Space Science Data Center.

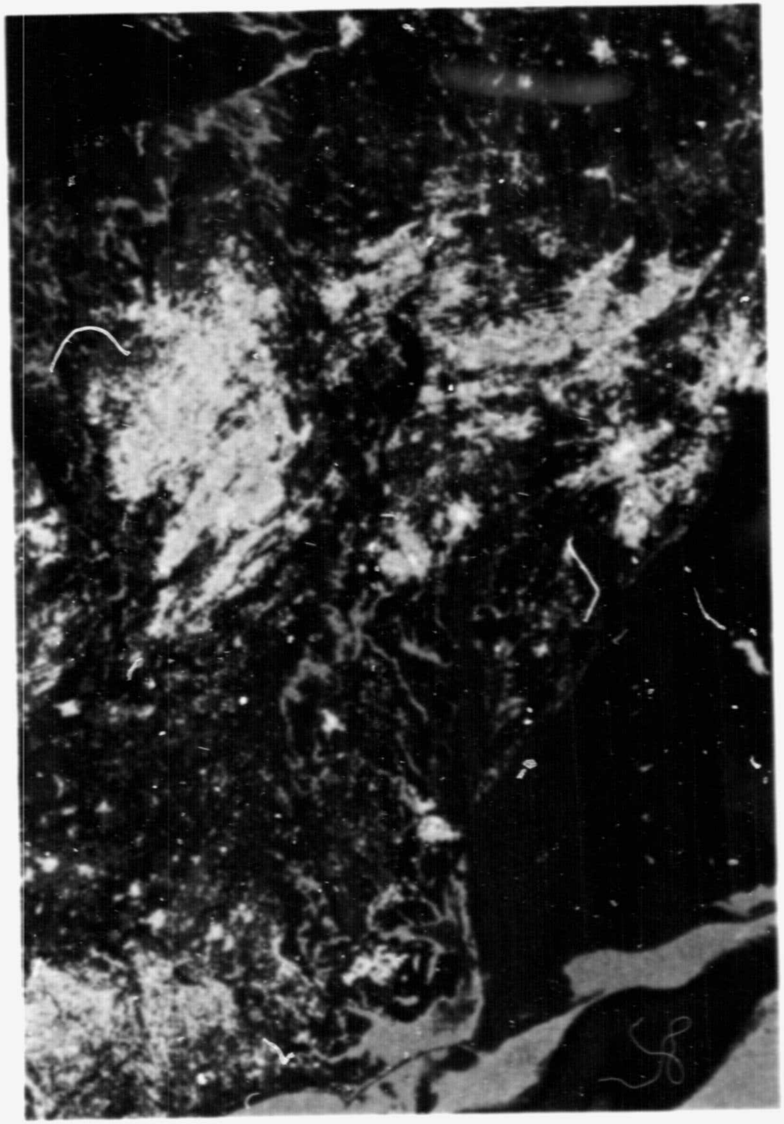
ORIGINAL PAGE
COLOR PHOTOGRAPH

Meteorological satellite (NOAA 4) thermal infrared image (computer enhanced) of large portion of Pacific Northwest, 1976

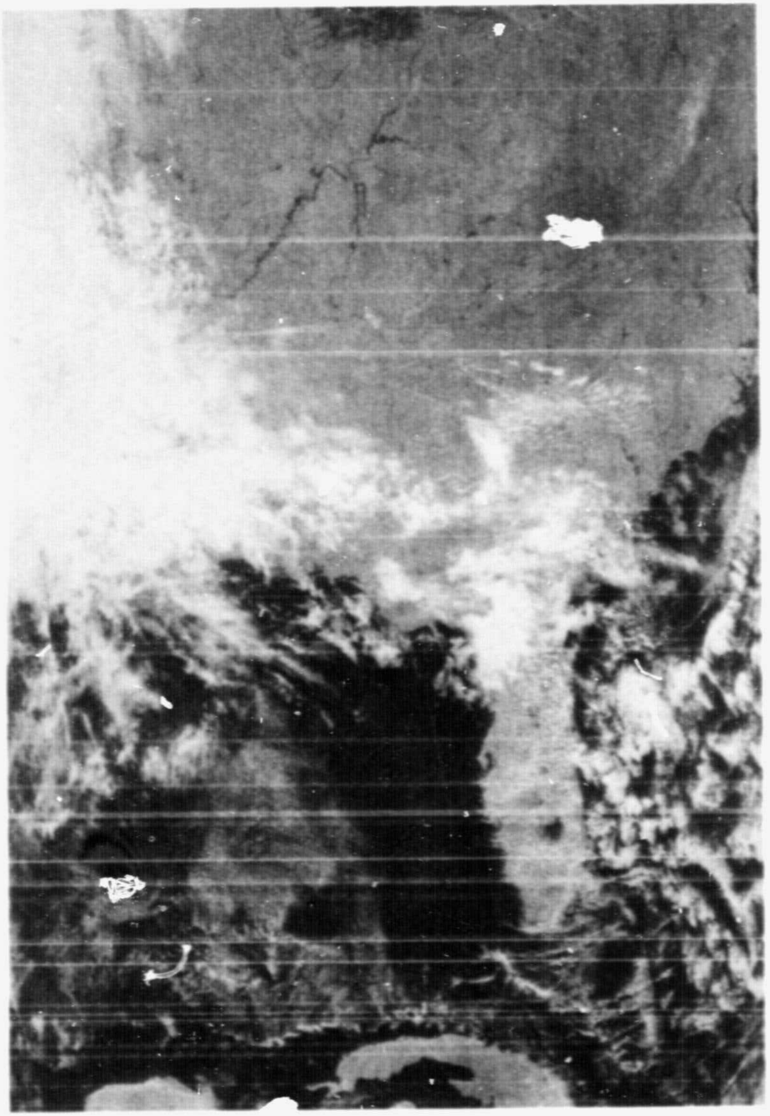
HCMM standard products include day infrared, night infrared, and day visible images. The illustration is a special elongated format which combines a set of images for color analysis. Examples of the color range shown are:

- Purple represents cold waters in Lakes Ontario and Erie.
- Blue represents the coldest water of the Atlantic Ocean.
- Green corresponds primarily to land masses and the Gulf Stream (lower right).
- Brown, yellow, orange, red, gray and white represent progressively warmer areas.

Special processed HCMM Image (Cape Hatteras to Lake Ontario, May 11, 1978)



A sample image of the Eastern U.S. recorded by the 6-band Coastal Zone Color Scanner (CZCS).

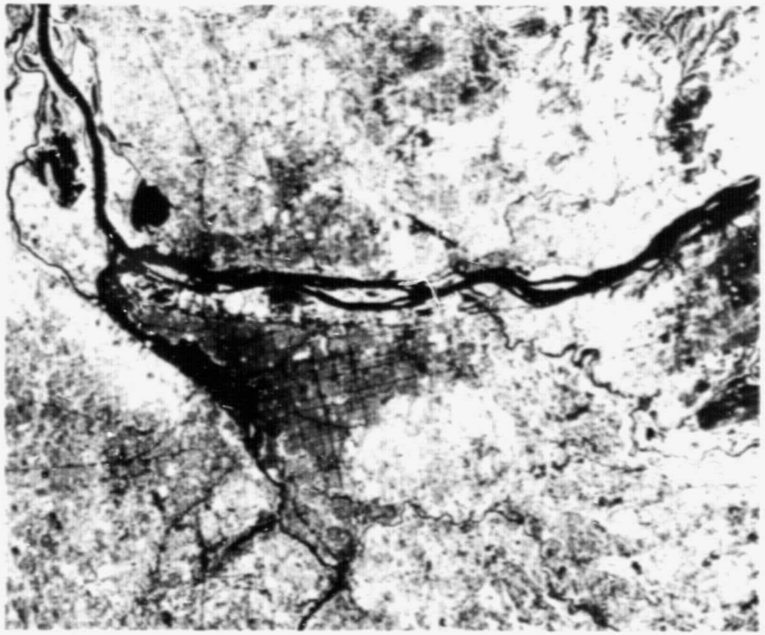


Coastal Zone Color Scanner (CZCS). The CZCS is a low resolution (800 m) multispectral scanner operating in the visible-to-thermal IR regions. It is presently being tested on Nimbus 7 and is the first sensor specifically devoted to ocean color measurements. This 6-band scanner system is designed to study processes in coastal areas by remote sensing of both color and temperature. The instrument is not intended to operate continuously, but only on command. Hard-copy photographs and computer-compatible tape data from the CZCS, processed to calibrated radiance or equivalent blackbody temperature, will be available on an unrestricted basis after initial validation is accomplished. For more information about data availability, contact the Environmental Data and Information Service/Satellite Data Services Division of NOAA.

Seasat. Launched in 1978, Seasat was the first satellite dedicated to the observation of ocean and coastal areas. It contained a comprehensive array of remote sensors to study wave heights, currents, surface winds, temperatures, ice fields, and coastal conditions. Unfortunately, the Seasat mission lasted less than four months, and only representative data were collected. The sensor of primary user interest on the Seasat platform was the Synthetic Aperture Radar (SAR) system. The most attractive feature on this device was its high spatial resolution (25 m). For SAR data acquired over coastal and land areas during the lifetime of Seasat, users should contact NOAA's Satellite Data Services Division.

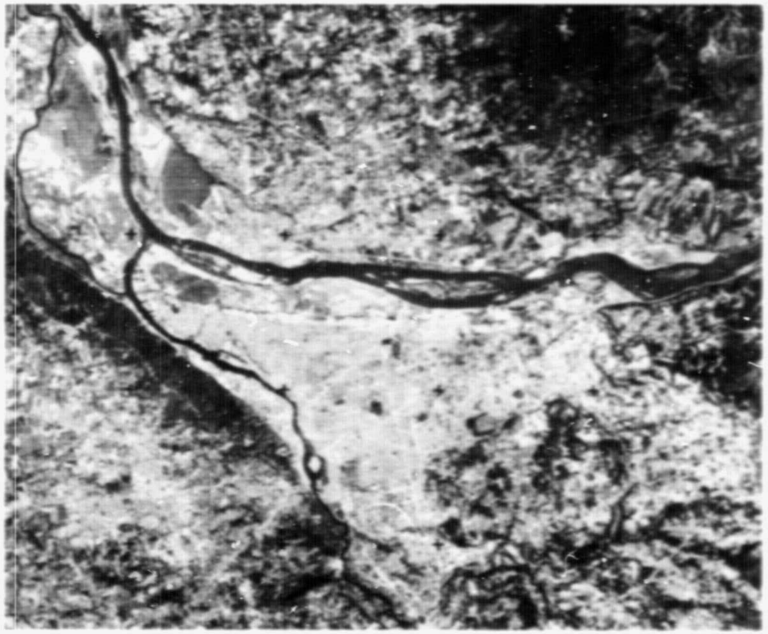
Landsat. The most readily available and useful Earth resources data are being provided by the Landsat series of satellites, formerly called the "Earth Resources Technology Satellite (ERTS)." Since 1972, three Landsats have provided extensive and repetitive multispectral data for most of the Earth's surface. In evaluating the application potential of Landsat data, the user should keep in mind the following characteristics of these satellite data: The data are available from two basic Landsat sensors; a Multispectral Scanner (MSS) and a Return Beam Vidicon (RBV) camera. The MSS provides imagery in four spectral bands

Single-band Landsat MSS image (Band 7, Portland, Oregon, July 1975)



ranging from the visible to the near infrared. The images are available to users in individual black and white bands or in three-band combinations called color composites. The latter are similar to color infrared photographs. Since a single Landsat MSS scene covers approximately 34,000 sq km with a ground resolution of 80 m, the data have been effectively utilized in large area resources studies, such as regional, geologic and land cover assessments. The MSS data are not recommended for large scale (larger than 1:24,000) site specific analyses and provide only limited stereo coverage.

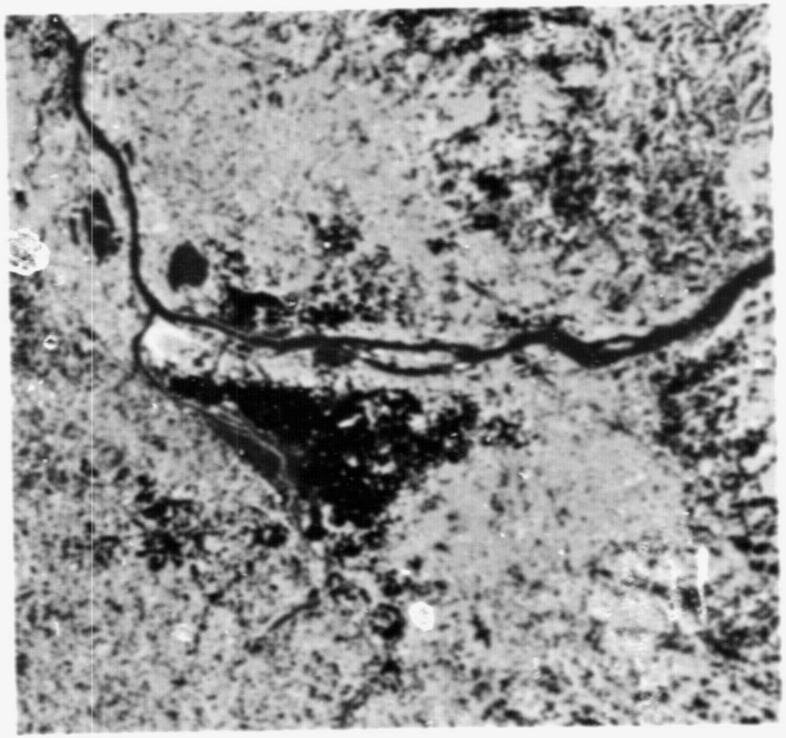
Landsat 3 RBV high-resolution image (Portland, Oregon, June 28, 1978)



The imagery obtained by the modified Return Beam Vidicon on Landsat 3 matches the area of an MSS scene by combining four frames, and has a ground resolution of 40 m. Although black and white only, these RBV images are gaining user popularity because they provide greater feature detail. All Landsat data are available to the general public at very reasonable prices and can be obtained in photographic and digital formats. The USGS EROS Data Center is the source for all Landsat data. Frequent users of Landsat data should request copies of "Landsat Data User Notes" published bimonthly by the EROS Data Center. For more detailed Landsat System and data characteristics information, the user can procure the "Landsat Data Users Handbook" from the EROS Data Center

Three-band, color composite of Portland, Oregon. (Landsat MSS image, July 1975)

Computer-produced land cover classification of the same area as in the left illustration



Future Satellites

Extensive experience with Landsat data during the 1970s and progress in space technology and remote sensing have resulted in program changes and plans which will have a dramatic impact on Earth resources satellite data availability and uses in the 1980s. Foremost among planned improvements are the extended spectral coverage (7 bands), higher spatial resolution (30 m), and faster data delivery times associated with the transition to Landsat D in late 1981.

These improvements in Landsat satellite surveys will be complemented by advanced remote sensing systems scheduled to be flown for various user groups in space shuttle missions. Examples of these systems include Stereostat, Large Format Camera, and the Shuttle Imaging Radar (SIR). These future data acquisition systems are discussed in the table that follows.

Summary of Major Satellite Sources of Earth Resources Data

I. Automated Satellites

Spacecraft	Launch	Character	Sensors of Interest	Wavelength or Frequency	Resolution
Landsat 1, 2, 3	1972, 1975, 1978	Prototype (Experimental)	Multispectral Scanner (MSS), Visible-Near IR, 4-Band	0.5 to 0.6 μm 0.6 to 0.7 μm 0.7 to 0.8 μm 0.8 to 1.1 μm	80 m
			Return Beam Vidicon (RBV) Visible-Near IR, 3-Camera	0.457 to 0.575 μm 0.580 to 0.680 μm 0.690 to 0.830 μm	80 m
			RBV 2-Camera on Landsat 3	0.505 to 0.750 μm	40 m
NOAA 4, 5	1975, 1976	Operational	Very High Resolution Radiometer (VHRR), Visible, Thermal IR	0.5 to 0.7 μm 10.5 to 12.5 μm	1 km
TIROS 14	1978	Operational	Advanced Very High Resolution Radiometer (AVHRR), Visible, Thermal IR	0.5 to 0.7 μm 10.5 to 12.5 μm	1 km
Nimbus 7	1978	Operational	Coastal Zone Color Scanner (CZCS) Visible, Thermal IR, 6-Band	.433 to .453 μm .510 to .530 μm .540 to .560 μm .660 to .680 μm .700 to .800 μm 10.5 to 12.5 μm	825 m
Seasat 1	1978	Experimental	Synthetic Aperture Radar (SAR)	1.275 GH_z	25 m
Heat Capacity Mapping Mission (HCMM)	1978	Experimental	Heat Capacity Mapping Radiometer (HCMR), Visible, Thermal IR	10.5 to 12.5 μm .5 to 1.1 μm	600 x 600 m 500 x 500 m 0.5°C Temperature Resolution

II. Manned Satellites

Gemini & Apollo	1965-1969		Handheld 70 mm camera and array of four Hasselblad cameras	Black and white and color photographs, first multi-band orbital photography	Varies - All very small scale

Spacecraft	Launch	Sensors of Interest	Wavelength or Frequency	Resolution
Skylab	1973-1974	Multispectral array (S190A) Visible - Near IR	0.5 to 0.9 μm	70 m
		High Resolution Earth Terrain camera (S190B), color and color infrared	Variable	25-35 m
III. Future Systems				
Landsat D	1981	Thematic Mapper (TM) Visible - Near IR, Thermal IR	0.45 to 0.52 μm 0.52 to 0.60 μm 0.63 to 0.69 μm 0.76 to 0.90 μm 1.55 to 1.75 μm 2.08 to 2.35 μm 10.40 to 12.50 μm	30 m (reflective bands) 120 m (thermal band)
		Multispectral Scanner (MSS)	Same as Landsat 3	Same as Landsat 3
Space Shuttle	1980s	Various Imaging Systems including cameras, scanners, and radar	Variable	Variable
Orbital Flight Test (OFT-2, 6)	1984	Shuttle Multispectral Infrared Radiometer (SMIRR)	Ten-Channel Near IR (non-imaging)	N/A
		Ocean Color Scanner (OCS)	Ten-Channel Visible	Low Resolution Images
		Shuttle Imaging Radar (SIR)	Modified Seasat-1 Radar to 50° Look Angle for Terrain Studies	
		Large Format Camera (LFC)	Color, color IR and Panchromatic images scale ~1:1,000,000 Stereo: 80% operational overlap, Focal Length: 30 cm	15-20 m
Stereosat	1980s	Three Line-Array cameras (aligned for Stereoscopic Viewing)	0.68 to 0.90 μm	15 m
National Oceanic Satellite System (NOSS)		Large Aperture Multichannel Microwave Radiometer (LAMMR)	6 Channels (6.6-9.4 GH_z)	1 km
		Coastal Zone Color Scanner (CZCS II)	8 Channels	825 m
Synchronous Earth Observation Satellite (SEOS)	Late 1980s	1.8 m Telescope		600 m (continuous scan) 16-60 m (fine scan)

Major Sources for Satellite Data and User Publications

Department of Interior (DOI)

U.S. Geological Survey
EROS Data Center
Sioux Falls, South Dakota 57198
(605) 594-6511 or FTS 594-6511

- Landsat Data Users Handbook (Revised 1979)
- Landsat Data Users Notes (Bi-monthly)

National Oceanic and Atmospheric Administration (NOAA)

Environmental Data and Information Services
National Climatic Center, Satellite Data Services Division
Room 606 World Weather Building
Washington, D.C. 20233
(301) 763-8111 or FTS 763-8111

- Satellite Data Users' Bulletin (Periodical)
- Environmental Satellite Imagery, Price List FY79
- National Holdings of Environmental Satellite Data of NOAA
- Environmental Satellite Data from NOAA
- Defense Meteorological Satellite Program
- Environmental Satellite Imagery (Monthly)

National Aeronautics and Space Administration (NASA)

Missions Utilization Office
NASA/Goddard Space Flight Center
Code 902, Greenbelt, Maryland 20771

National Space Science Data Center
NASA/Goddard Space Flight Center
Code 601, Greenbelt, Maryland 20771
(301) 344-7354 or FTS 344-7354

- Heat Capacity Mapping Mission Users' Guide (December 1978)
- Users' Guide for Heat Capacity Mapping Mission (HCMM) (September 1976)
- Earth Resources Satellite Data Application Series (various publications starting in 1980)
- Data users' bulletins for various satellite missions (periodical)

Sources for Publications and Information

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Dr. Dale R. Lumb
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NASA/Ames Research Center, Mail Stop 242-4
Moffett Field, California 94035
(415 965-5900

In addition to the publications listed in this guide, active users of Landsat data may also be interested in the Landsat Data Users Handbook (revised edition) and Landsat Data Users Notes (Newsletter) published by

U.S. Geological Survey
EROS Data Center
Sioux Falls, South Dakota 57198
(605) 594-6511

Suggestions intended to increase the usefulness of future editions of this document may be forwarded to any of the NASA offices listed above